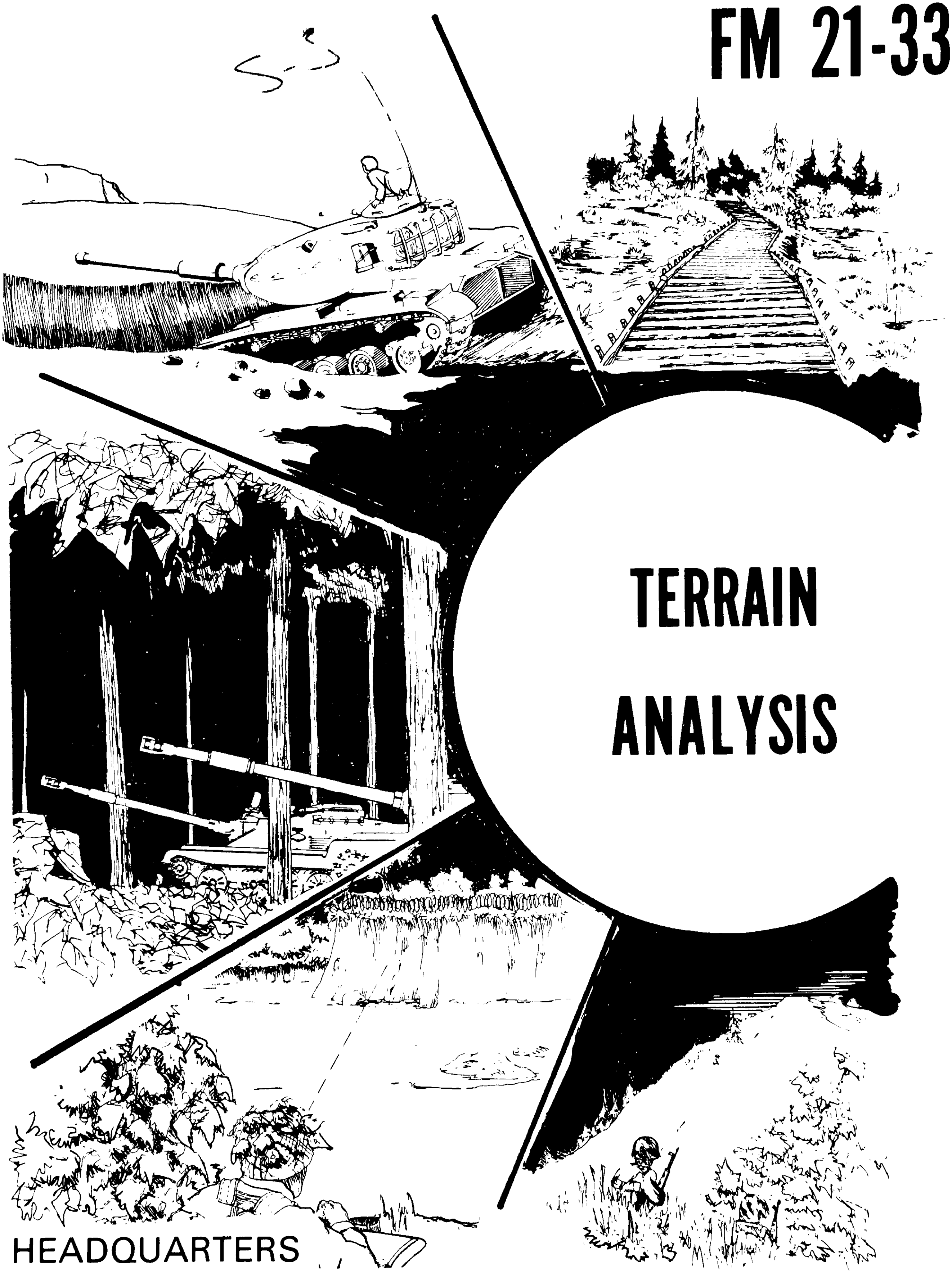
FM 21-33



TERRAIN ANALYSIS

HEADQUARTERS
DEPARTMENT OF THE ARMY

MAY 1978

The word "he" or "his" in this publication is intended to include both the masculine and feminine genders and any exception to this will be so noted.

FIELD MANUAL
No. 21-33

HEADQUARTERS
DEPARTMENT OF THE ARMY
Washington, DC, 15 May 1978

TERRAIN ANALYSIS

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CHAPTER 1

INTRODUCTION

PURPOSE

This manual is intended to assist you in identifying the duties of a Terrain Analyst, and to serve as a reference when you are performing such duties.

SCOPE AND RELATION TO OTHER MANUALS

You will find here the procedures that are followed in performing the tasks that a Terrain Analyst is expected to be able to do. This manual does not repeat procedures that are explained in other manuals or in courses that should be completed before you enter the Terrain Analyst course, but it tells you where to find such information when you need it. If you have the right reference materials you can readily find the answers to questions of technique and procedure that may arise in your study and work. A list of manuals that are useful for a Terrain Analyst is found in the Appendix.

CHANGES AND COMMENTS

The Army would like to have your comments and recommendations for improving this publication. Use DA Form 2028 (Recommended Changes to Publications), giving the specific page, paragraph, and line of the text for which the change is recommended and reasons for the proposed change. DA Form 2028 should be sent direct to the Commandant, U.S. Army Engineer School, Fort Belvoir, VA 22060.

WHAT IS TERRAIN ANALYSIS

Terrain Analysis is the process of analyzing a geographical area to determine the effect of the natural and manmade features on military operations. The product of terrain analysis is a terrain study, which is one of a number of sources of information (maps, photographs, interrogation, etc.) on which a commander can base his decisions.

Terrain is defined as a portion of the earth's surface, including manmade and natural features. Terrain data (or terrain information) are raw data in any form about a segment of terrain. When these data have been evaluated, analyzed, interpreted, and integrated, they become terrain intelligence, which may be presented in a number of different formats, one of which is a terrain study.

Terrain intelligence is thus one aspect of operational intelligence. As an enlisted terrain analyst, your duties will most likely be to produce terrain intelligence for use at the tactical level of operations. Operational intelligence, however, is required at all levels, so your product may be used either by the commander of the organization you are in or by higher headquarters.

LEVELS OF PROFICIENCY IN TERRAIN ANALYSIS

A beginning terrain analyst will not usually be called on to prepare detailed terrain studies, but he should know how to go about it in order to develop increased proficiency with experience. Ordinarily, a beginner (grade E5) will be required to extract basic facts from his data sources and present them on factor overlays. At the next level (E6) he should be able to interpret these facts in terms of military activities and to combine the information from several factor overlays in order to answer specific questions. At the senior level (E7) he should be able to supervise the work of several analysts, to prepare more complex terrain studies, and to predict the performance of various types of equipment under the prevailing conditions of weather and season.

THE INTELLIGENCE CYCLE

Since intelligence may be useless or even dangerous unless kept up-to-date, its production and revision must never end. This continuing activity is carried on through a four-step cycle called the intelligence cycle: (1) plan to collect data, (2) collect required data, (3) process collected data into intelligence, (4) disseminate the intelligence. Details of these four steps will be described in the rest of this manual. It is called a cycle because after you complete the four steps, you begin over to keep your intelligence up-to-date.

SKILLS YOU WILL NEED

To be a terrain analyst you must be thoroughly proficient in topographic map analysis, and map interpretation. Almost as important are skills in interpreting photographic and other remotely sensed imagery. These skills include the use of formulas and measuring techniques, both on photographs and maps and on the ground. You also should know how to do cartographic drafting and should be able to write clear, factual reports.

Before starting the Terrain Analyst Course you should have either courses or practical experience in Soils Analysis, Image Interpretation, and/or Map Compilation.

CHAPTER 2

COLLECT DATA

SECTION 1. KINDS OF DATA

As a terrain analyst you are responsible for analyzing data that come to you from a variety of sources. Part of your job is to collect the data yourself. You should know something about the sources of information in order to be able to request it when needed, and you should know the advantages and disadvantages of each kind.

Your three main sources will be photographs, maps, and written reports. In this chapter we will consider what kind of information you can get from each of these sources, and where you can get them. There may be times when you will have to depend on your own resourcefulness to get the data that you need, but normally your detachment commander will order it for you provided you can tell him accurately what you need.

REMOTE SENSING

Much of the data that you will be called on to analyze will be obtained by aerial reconnaissance. These data usually are in the form of photographs, but in recent years other methods have been devised for "remote sensing." Therefore we use the more general term imagery when talking about the results of aerial reconnaissance. There are many different kinds of imagery in use today and others under experimentation. Those discussed below are the principal ones that you should know something about.

PHOTOGRAPHIC IMAGERY

(1) Panchromatic

Panchromatic photography is in black and white, but the film is sensitive to all visible wavelengths. This means that all colors will register on the film, and differences in tone on the photograph will vary with the intensity of the object's color rather than its wavelength. All black and white film used in aerial photography is panchromatic. Despite the many new films and techniques that have been developed, black and white panchromatic is still the most frequently used film.

(2) Infrared Panchromatic

Infrared black and white film is sensitive to blue-violet and infrared light. It is sometimes exposed through red filters; then the exposures are made by red and infrared wavelengths only and called "near-infrared." This type of film is used mostly for detection of different types of vegetation or plant disease. The Army uses it for detecting camouflage because it enables an interpreter to tell cut from live vegetation, and vegetation from artificial material such as nets and paint.

(3) Infrared Color

This film, originally designed by Kodak as Ektachrome infrared aero film, is a false-color, reversal film used for camouflage detection. It shows colors that are false for natural features. Natural deciduous foliage appears red and painted artificial foliage appears purple. This film is also used for detection of plant disease, insect infestation, and water pollution.

(4) Conventional Color

This film, although expensive and more critical to expose and process, is valuable for identifying soil types, rock outcrops, industrial stockpiles, subsurface water, and shorelines. It is rarely used under field conditions.

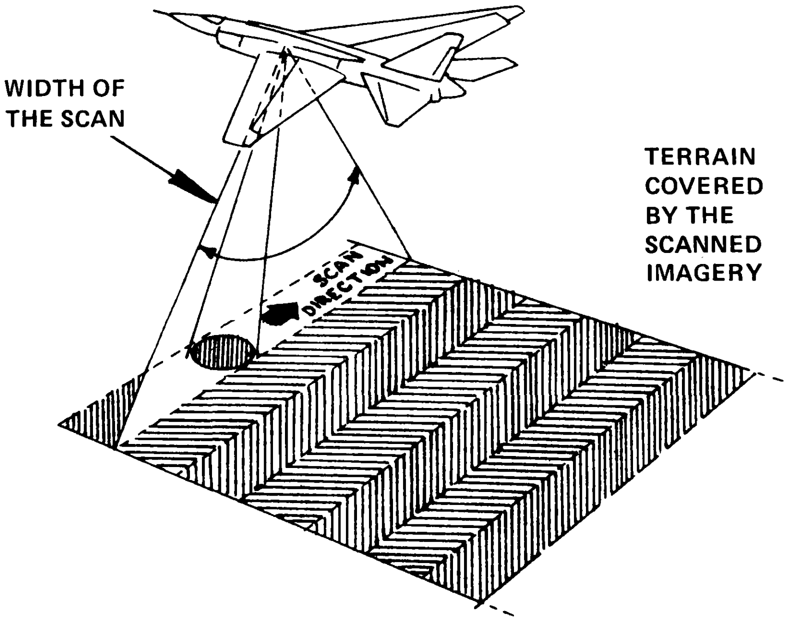
(5) Multiband

Multiband photography is still in the experimental stage. Special cameras have been built using many lenses (up to 9) at the same time, each with a film of different spectral sensitivity. The camera photographs an area with all these films and lenses simultaneously. Each film records different data about different objects because each object reflects different spectral energy. These objects (terrain features) can now be detected as different tones of gray on the different films, whereas they may appear the same on one type of film. Further research is needed before multiband will be operational under field conditions.

NONPHOTOGRAPHIC IMAGERY

(1) Thermal Infrared

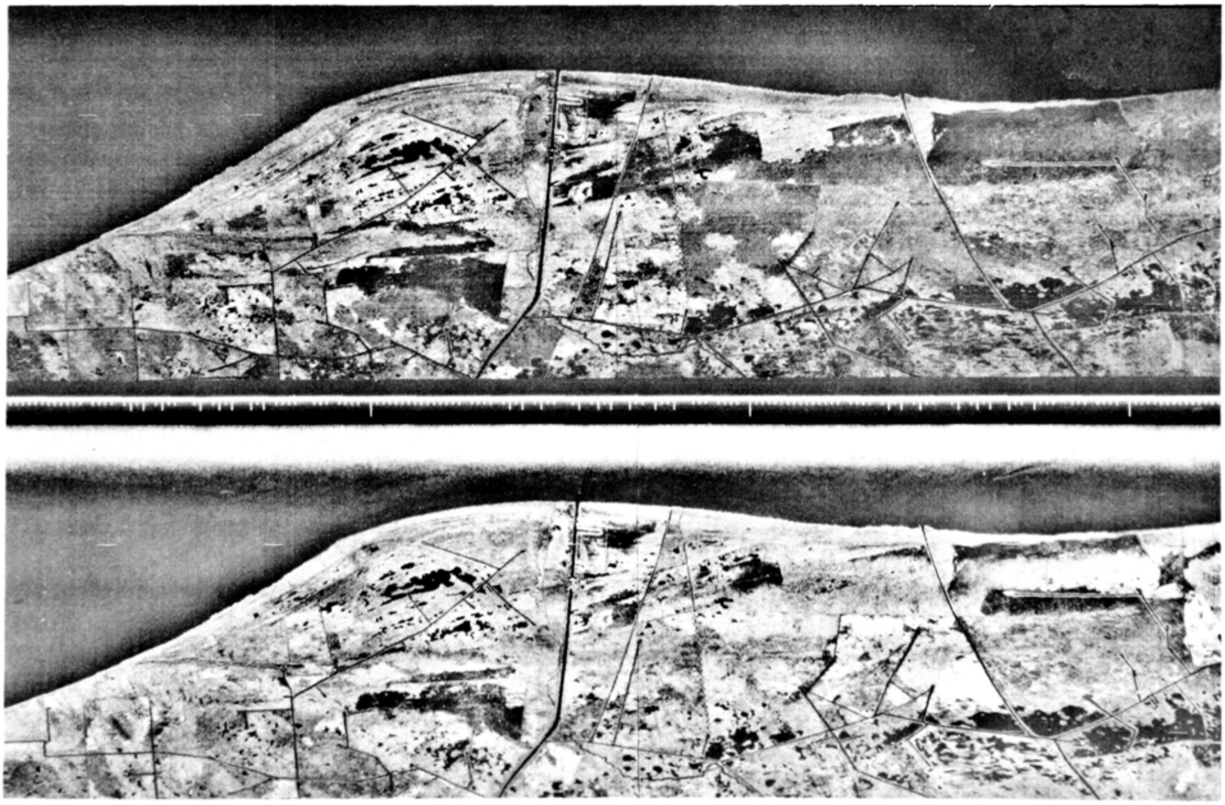
"Thermal" means having to do with heat. Accordingly, thermal infrared records the heat of terrain features. A bare rock surface is hotter in the bright sun than green grass. Thermal infrared photographs the hotter feature as brighter. This infrared image is a photograph of an image that appears on an electronic tube something like a television tube. This tube and the total infrared sensor system are in an airplane. The sensor scans the terrain by swinging from side to side as the airplane flies ahead.



The scanner, therefore, "paints" the ground in narrow strips. These strips are photographed all together to make an image like a photo from a strip camera. The imagery can be used to detect fire when concealed by smoke, as in a forest fire. It has many other potential uses, such as mapping seismic fault lines, identifying minerals, crop diseases, soil moisture content, cool underground springs, and heat from vehicles. Most military uses are classified.

(2) Radar

Radar imagery, particularly Side-looking Airborne Radar (SLAR), is similar to thermal infrared in many respects. The radar "looks" out from each side of the airplane in a narrow beam. Then the airplane flies ahead, and the radar takes another look sideways. These "looks" (or side scans) are added to each other on the radar display tube. A picture is taken of this tube and this picture is your SLAR imagery. Again, like IR, the terrain covered is in a strip like the photo from a strip camera.



Side-looking Airborne Radar (SLAR) Images

(3) Satellite Transmitted

Photos of the earth are transmitted from satellites. These are not direct photos but are photos of a cathode ray tube, like a television screen. The satellite contains a video tape recorder like a television camera. When the camera is turned on a photo of a portion of the earth is made on video tape. This video tape is transmitted to the earth and reconstituted on a TV type screen and photographed.

MAPS

A topographic map is the most important tool of a terrain analyst. You will see in chapter 5 how you can use "topo" maps for analyzing drainage, slope, settlements, and many other aspects of terrain. So it's important to have topographic maps that are as recent and accurate as you can get.

There are also other kinds of maps. A planimetric map is one that does not show relief. They are used especially for mapping manmade features such as city streets, where it is important to show a lot of detail without the "clutter" of contour lines.

Another kind of map is called thematic. These are maps that are designed to show just one feature or "theme," so they are often called special purpose maps. Examples would be maps of average rainfall, location of certain minerals, and distribution of population. The factor overlays that you will be making (see chapter 5) are a kind of thematic map.

TEXT

The third major source of data is words--printed, typed, written or spoken. Printed words (or text) that are available to everyone are called "open literature." This is the kind of material that you can get from a library, bookstore, or magazine stand. The term refers especially to scholarly writing such as books and articles in recognized journals. The open literature of geography contains a lot of information that is valuable for terrain analysis because it is carefully done, usually well illustrated, and easy to obtain.

There are also many other kinds of text that can be useful to you. Travel accounts, guidebooks, industrial advertising, and chamber of commerce publications can all tell you something about an area. You can even learn a good deal about local business and industry from a telephone directory.

Military intelligence reports are another essential source of information, but they have to be handled more carefully than open literature because they are usually classified. Their scope varies from an entire country, as in the NIS (National Intelligence Surveys) produced in Washington, to special intelligence reports of a local area which would be typed in the field with just a few carbon copies.

A good source of data, although not always reliable, is government reports of various kinds. Most governments publish statistics on climate, streamflow, population, agricultural produce, industrial production, and a variety of other subjects. Keep in mind, however, that in some countries these figures may be "slanted" to support some governmental policy, while in others it simply may not be possible to get reliable figures. For example, where a population lives mainly by subsistence farming, most of the produce may never be sold and so no record of it is made.

SECTION 2. WHERE TO GET IT

MILITARY INTELLIGENCE SOURCES

In the field your first source for data is military intelligence. It is MI's job to get and process the data that you will use in terrain analysis, especially data from aerial reconnaissance. When you need photos or other imagery of a certain area, you can request them from MIBARS (Military Intelligence Battalion, Aerial Reconnaissance and Surveillance). If you are attached to a division headquarters, you should have close relations with the division MI company. Requests for data should go through your detachment commander.

AERIAL PHOTO AGENCIES

In addition to the imagery that you can get from MIBARS, there are many sources of aerial photography that can be used in peacetime. The U.S. Department of Agriculture maintains a library of aerial photographs covering most of the United States from which photos can be ordered:

Western Aerial Photography Laboratory
Administrative Services Division
ASCS-USDA
2505 Parley's Way
Salt Lake City, Utah 84109

You can obtain a map showing the "Status of Aerial Photography in the United States" by writing to:

National Cartographic Information Center
USGS National Center
12201 Sunrise Valley Drive
Reston, Virginia 22092

This map shows areas that have been photographed either by government agencies or commercial firms, and tells where you can obtain prints.

Most of the states also have agencies that maintain photo libraries. All of these sources make a charge for furnishing photographs.

Air photos are available for purchase from commercial aerial survey firms in the United States and some other countries. The cost is often higher than that of photos from government agencies, but the photos may have larger scales than are otherwise available. Some of these companies are listed in the USGS map described above, while others are given regularly in the journal "Photogrammetric Engineering and Remote Sensing."

MAPPING AGENCIES

Maps for the U.S. Army are produced by the Topographic Center of the Defense Mapping Agency (DMA). Other major elements of DMA are the Hydrographic Center, which mainly produces charts for the Navy, and the Aerospace Center, which is concerned with aeronautical and space navigation charts. So most of the maps you will be using come from the DMATC. To obtain all necessary information about maps of the world, request a copy of "Department of Defense, DMA Catalog of Maps, Charts, and Related Products" from:

Defense Mapping Agency Topographic Center
Washington, D.C. 20315

This very extensive catalog is published in four parts. Part 3, Topographic Products, has six volumes, each dealing with a portion of the world. It contains indexes of all DMA maps and other products available. It also contains instructions on how and where to order maps and products, for example, aerospace, hydrographic, topographic and air target material products, city maps, trig lists, map gazetteers, and digital topographic data. Since the names and locations of map depots change from time to time, up-to-date ordering information should be obtained from the above address.

Nearly all foreign governments also maintain one or more mapping agencies. Although DMATC maps cover all parts of the world, you may be able to get more up-to-date maps through local sources when you are overseas. The Library of Congress maintains a list of these sources, "Published Sources of Information about Maps," and "Selected List of Map Publishers and Sellers," which you can obtain from the Geography and Map Division, Library of Congress, Washington, D.C. 20540.

In addition to DMA, there are many other government agencies, both in the United States and abroad, that produce maps. Usually these maps are for special purposes. For example, the U.S. Forest Service and its counterparts in other countries issue maps showing cover type and other aspects of forest stands. Some of these are very useful in terrain analysis. You can also get government maps showing transportation routes, mining activity, recreational areas, and other information about the terrain. Some governments put out maps showing types of land use.

Private mapping agencies are also active in some countries. All European countries are covered by road maps that are distributed (for a small charge) by gasoline vendors. Automobile clubs are active in many countries and some of them produce good road maps. The maps that are sold in bookstores frequently give detailed information about city street patterns.

WRITTEN MATERIAL

A good place to start getting information about an area is the local library, either in a town or on an Army post. You will probably find travel accounts and perhaps scientific works about the country, state, or locality you are concerned with.

Geographical publications are especially useful. Some of the leading ones written in English are:

National Geographic Magazine
(the well-known magazine published in Washington, D.C., with excellent illustrations and frequent map supplements)

The Geographical Review
(a scholarly journal produced quarterly by the American Geographical Society, Broadway at 156th St., New York, NY 10032)

The Geographical Magazine (an illustrated monthly with articles by specialists for the general reader, published by New Science Publications, 128 Long Acre, London WC 2E9QH, England)

SOURCES OF CLIMATIC DATA

Fortunately there is no lack of good climatic data for most of your needs. The U.S. Government and most foreign governments have extensive data collection and summarization programs. Weather data are widely disseminated and are seldom if ever classified. Cooperation and exchange of weather information and data are normally restricted only in wartime.

The Air Weather Service (AWS) of the U.S. Air Force has the responsibility of providing you with any and all data you will require--both stateside through the Environmental Technical Applications Center (ETAC) and overseas through the Weather Wing or detachment in your theater of operations. (See sections 2-19 and 2-20 of FM 30-10.) Requests for ETAC's support are made by standard military letter and addressed to: USAF ETAC, Scott AFB, IL 62225. A concise statement of the problem in terms of either the environmental factors involved or of the climatological information desired is all that is needed. If the problem cannot be adequately defined or the request properly stated, then Air Weather Service staff meteorologists are available to assist. The request must state the date the solution or information is needed and the priority of the program or project requiring support. A staff meteorologist can be contacted by phone before writing the formal letter. Remember that the Air Weather Service does have the mission to supply Army elements with climatic data and even analysis.

Probably a majority of the data you will require for your studies and climatic summaries already exists in published form and in the open literature. It will be found in any good library in your area of operations in official government publications. It will also occur in a wide variety of climatic and geographical textbooks and even in some travel guides. It is good practice to get started looking for materials for your climatic summary or study while waiting for officially responsible agencies to supply you with what you need. Contact your local National Weather Service office or U.S. Air Weather Service officer and see what they might have on hand that they could lend or supply. Then try large public or university libraries for additional sources, and consider the possibility that what you need may already exist in an appropriate published form so that all you need to do is copy it.*

For some foreign countries and areas remember that a greater concern for weather data may rest with an agency outside of the meteorological service of that country, such as a hydrological (irrigation/flood warning) service, an agricultural bureau, or even an association of airlines at some major airport. Unusual sources of good data can sometimes be found, such as records at a resort hotel, a marina, a TV station, or a mine at a lonely location.

Another source of data which requires more experience to use is cloud photography and other types of imagery taken from satellites by the Defense Meteorological Satellite Program (DMSP) for use of military personnel. Global DMSP data are received and processed at the Air Force Global Weather Central (AFGWC), Offutt AFB, Nebraska.

Conventional weather maps produced in the major capitals of the world, and river stage data taken at various gaging stations on a stream, are other sources of usable data. Governments below the national level also take and keep weather data--although these are generally for special studies and are of shorter durations. It is a good rule never to take "no data available" as an answer without digging just a little bit further.

**See especially section 23 of the National Intelligence Surveys (NIS), completed for most countries of the world. These climatic sections do not get out of date.*

CHAPTER 3

MANAGE THE FILE OF DATA

After you collect the information (data), you need a place to store it and you must be able to find it when you need it. No matter how impressive the data may be, it's worthless if you put it somewhere and can't find it or can't tell what it is when you do. So you must file it, label it, and be able to find it again and recognize it. Keep your filing method simple enough that it works. The very sophisticated systems for titling, plotting, and handling photography described in TM 30-245, Image Interpretation Handbook, may not be suitable for field conditions.

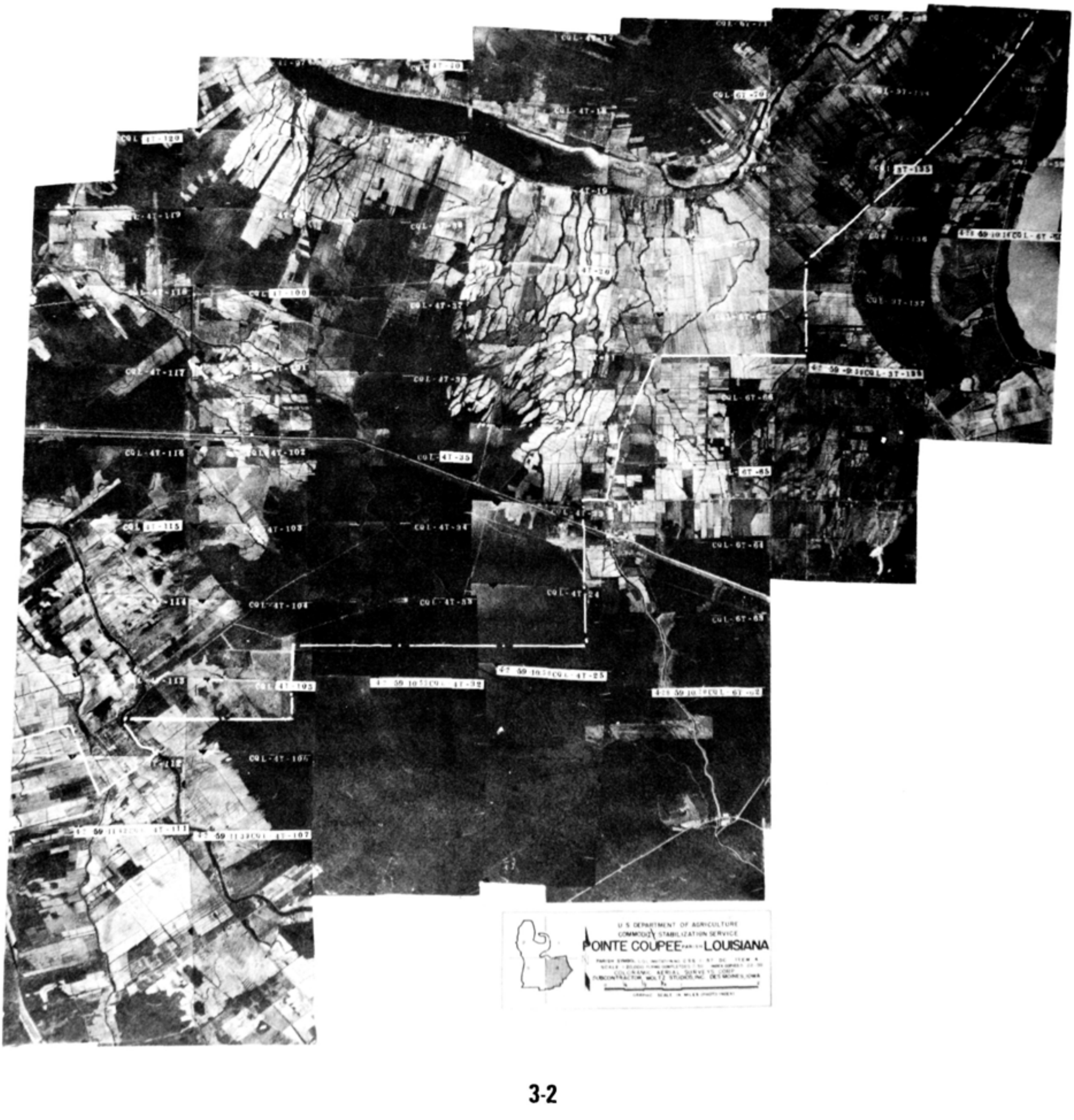
So: 1. KEEP IT SIMPLE
    2. KNOW WHERE IT IS
    3. KNOW WHAT IT IS

Almost all data you collect will be in the form of photos, maps, or documents and books, occasionally supplemented by nonphotographic remotely sensed imagery. The data is stored and retrieved either (1) manually (by hand), (2) by automation using machines to do part of the job and manually to take care of the remainder of the job, or (3) by automation using machines to do all of the job.

SECTION 1. FILE PHOTOS

The simplest ways to manage aerial photo files are with either photo indexes or map overlay plots. Titles are important on all three--the photos, the indexes, and the plots.

Photo Index Mosaic. An uncontrolled photo index mosaic is the fastest way to show photo coverage providing you have a copy camera available. You lay the photo prints from each flight line over each other by matching detail. Staple them in place. Add a title and a legend and draw the map area corner ticks. (See TM 30-245, page 5-16). Have it "shot" and reduced on the copy camera. If no copy camera is available, make an index plot of the photos.


U S DEPARTMENT OF AGRICULTURE
COMMODITY STABILIZATION SERVICE
POINTE COUPEE PARISH LOUISIANA

Index plot of Photographs. Drawing details on plots is time-consuming, so be sure you have enough time to draw the details you need. Use a plotting template on an overlay, over a map, usually a 1:250,000, and draw the outline of the area covered on the map by the photo. (See TM 30-245, page 5-16.). If flight lines are regular, you may plot only every fifth photo, as well as the first and last photos of the flight line. For examples of plots of oblique, strip, and panoramic photos, see TM 30-245, pages 5-17 and 5-23.

Titles of Photos. There are many systems of standarized titling. (See TM 30-245, chapter 4.). Some titles are brief and some are detailed.

The title is exposed directly on the film, in the corner of each film frame, as the photo is taken. It appears as a small rectangular box or "block". This block contains three columns of dots which are in binary code. When translated by means of a computer, the code tells the following information about each photo frame:

(1) Date (of photo)
(2) Photo-taking unit
(3) Sortie number
(4) Camera type, or sensor
(5) Barometric altitude
(6) Heading of the airplane
(7) Drift
(8) Roll
(9) Pitch
(10) Time (GMT)
(11) Latitude of the airplane (when the photo was taken)
(12) Longitude of the airplane (when the photo was taken)
(13) Radar altitude
(14) B/N (bombadier/navigator mode of operation)
(15) SLAR (side-looking airborne radar) mode
(16) ELRAC (electronic reconnaissance accessory set)

Other photo titling methods, such as alphanumeric data blocks, are discussed in TM 30-245.

Should you acquire photos with no titles, you will have to title them manually. On the film leader, write the name of the area covered by the photos. The minimum to write on each film frame or print is the roll number, date, and the frame number. Additional data may be written elsewhere, such as on the film roll can, the package of prints, or the photo data card.

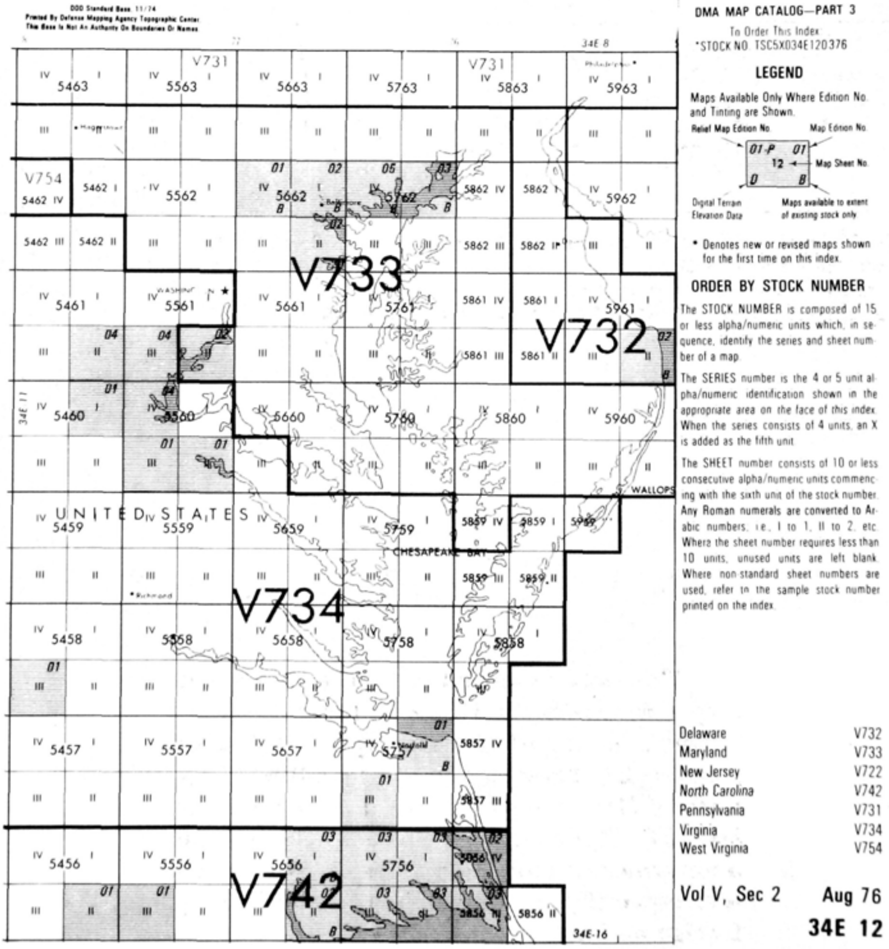
Photo Data File Cards. If you are required to store a large amount of photography and sensor imagery, you may have to use a card file to control or search for photos.

Depending upon the size of your collection of photos and sensor imagery, you may need a cross reference file on 3x5 cards. For example, suppose a request is, "What is all the latest coverage you have over Tan An?" Then you need a file by date of coverage and by the area of Tan An. Other cross references can be by country, province, source, type of imagery, or scale.

SECTION 2. FILE MAPS

Map Indexes. The indexes of foreign maps that you will use most frequently are those by the Defense Mapping Agency Topographic Center (DMATC), formerly known as Army Map Service and later as the Army Topographic Command (TOPOCOM). These are described in TM 5-248.

DMATC maps, however, do not provide complete coverage, especially within the United States, Puerto Rico, and the U.S. territories. DMATC is responsible primarily for foreign maps, and the U.S. Geological Survey (USGS) is responsible for domestic maps. (See chapter 2.) So you will need USGS maps for complete United States coverage. The USGS maps are indexed by a different system than those of DMATC. USGS indexes maps by standard quadrangles of 7-1/2 minutes, published at a scale of 1:24,000, and by 15 minutes, at a scale of 1:62,500 or 1 inch to the mile.* Most USGS maps of the U.S. are published at those scales in addition to 1:250,000 and 1:1,000,000. Alaska is published only at 1:63,360 and 1:250,000. Puerto Rico is published only at 1:20,000, 1:120,000, and 1:240,000.



DMA MAP CATALOG—PART 3

To Order This Index:
*STOCK NO. TSC5X034E120376

LEGEND

Maps Available Only Where Edition No. and Tinting are Shown.

• Denotes new or revised maps shown for the first time on this index.

ORDER BY STOCK NUMBER

The STOCK NUMBER is composed of 15 or less alpha/numeric units which, in sequence, identify the series and sheet number of a map.

The SERIES number is the 4 or 5 unit alpha/numeric identification shown in the appropriate area on the face of this index. When the series consists of 4 units, an X is added as the fifth unit.

The SHEET number consists of 10 or less consecutive alpha/numeric units commencing with the sixth unit of the stock number. Any Roman numerals are converted to Arabic numbers, i.e., I to 1, II to 2, etc. Where the sheet number requires less than 10 units, unused units are left blank. Where non-standard sheet numbers are used, refer to the sample stock number printed on the index.

Delaware	V732
Maryland	V733
New Jersey	V722
North Carolina	V742
Pennsylvania	V731
Virginia	V734
West Virginia	V754

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* 1 Inch to the mile is actually 1:63,360, but the difference is negligible at this scale.

USGS indexes are by state and each quadrangle has a name, not a number like DMATC maps. The name is usually a prominent feature such as the largest city or town in the quadrangle, and the names of adjacent sheets are shown in the margins. You must have an index to know the names of USGS sheets that are more than one sheet removed from the sheet you have.

NATIONAL TOPOGRAPHIC MAPS

Series	Scale	1 inch represents	Standard quadrangle size (latitude-longitude)	Quadrangle area (square miles)	Paper size E-W N-S width length (inches)
7½-minute	1:24,000	2,000 feet	7½ x 7½ min.	49 to 70	[1] 22 x 27
Puerto Rico 7½-minute. . .	1:20,000	about 1,667 feet	7½ x 7½ min.	71	29½ x 32½
15-minute	1:62,500	nearly 1 mile	15 x 15 min.	197 to 282	[1] 17 x 21
Alaska 1:63,360	1:63,360	1 mile	15 x 20 to 36 min.	207 to 281	[2] 18 x 21
U.S. 1:250,000. .	1:250,000	nearly 4 miles	[3] 1° x 2°	4,580 to 8669	[4] 34 x 22
U.S. 1:1,000,000.	1:1,000,000	nearly 16 miles	[3] 4° x 6°	73,331 to 102,759	27 x 27

[1] South of latitude 31° 7½-minute sheets are 23 x 27 inches; 15-minute sheets are 18 x 21 inches.

[2] South of latitude 62° sheets are 17 x 21 inches.

[3] Maps of Alaska and Hawaii vary from these standards.

[4] North of latitude 42° sheets are 29 x 22 inches. Alaska sheets are 30 x 23 inches.

The only other index of complete world map coverage is the U.S. Coast and Geodetic Survey's index of aeronautical charts. (See chapter 2.) These indexes are numbered by a still different system from that of USGS or DMATC. The charts can serve as a useful base upon which to plot other maps to show coverage, especially of foreign maps (published by foreign nations).

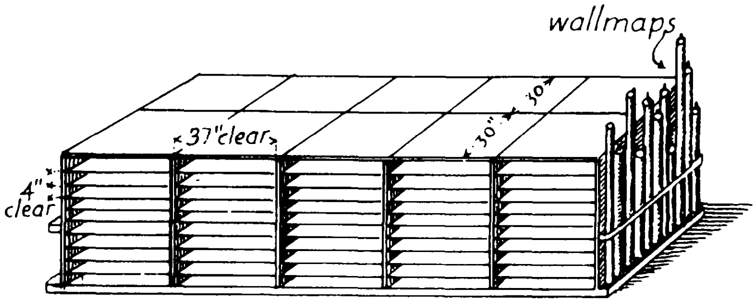
Map Plots. Maps are easy to plot. Simply draw the outline of the map coordinates on a smaller scale map or on an index of another map series. You can use an overlay to avoid marking up a base map or the index. Map overlay plots are a good way to compare the coverage of different maps of the same area.

Map Titles and Files. If maps which you are filing do not have a title in the lower right-hand corner, you may need to write one in order to find it easily when searching the map file. Maps are best filed in folders of strong (wrapping type) paper 24" x 36". They can be easily and quickly made in the field with masking tape or staples, and can hold 30 or more maps.

A title of the contents should be written on the lower (front) right-hand corner. These folders can be numbered in order to return them to their proper place in the file. A good idea is to include a second copy of the map index in each folder to indicate its contents. Keep the master copy of all indexes together in a binder.

Maps can be grouped in folders regionally by countries, provinces, or by some other geographical breakdown. If the map is too large for the folder, it is better to fold the map once or twice than to roll it. A rolled map is difficult to identify, space consuming to store, and a pain to unroll to look at.

Two map folders fit nicely side by side in a standard map file (42" x 54"). The map file comes in five-drawer sections. Map files can be easily improvised from open-end wooden cases, and the top can be used for spreading out maps.



SECTION 3.
PLOT REMOTELY SENSED IMAGERY

Infrared (IR) imagery, described in TM 30-245, pages 2 through 25, is produced by an airborne scanning unit combined with the forward motion of the aircraft. The result is an effect of "painting" narrow strips on the ground. These strips are added to each other as the aircraft moves forward and the total ground coverage is similar to that of visual strip photography.

Side looking airborne radar (SLAR) imagery is produced by a method similar to the method used to produce IR imagery. The radar "looks" out from each side of the airplane in a narrow beam. Then the airplane flies ahead and the radar takes another look sideways. These "looks" (or side scans) are added to each other on the radar display tube. A picture is taken of them, like taking a picture of your TV screen. This picture of the radar is your SLAR imagery. So you have a photograph of a recording display in both cases, SLAR and IR, but of two different types of energy. In the case of SLAR, the energy is a radio wave and in the case of IR, it is a heat wave.

Since the ground coverage of SLAR and IR is similar to that of visual strip photography, you plot all imagery about the same way. Simply plot the width of ground covered by two parallel lines on an overlay over a base map. Use symbols and annotations as indicated in FM 30-245, pages 5 through 17. Frequently the plot will "run" from one topographic sheet onto the next. You will need many large-scale maps, or better, plot to a small-scale one such as 1:250,000.

CHAPTER 4

USE THE DATA FILE

SECTION 1. ANALYZE SOURCE MAPS

INTRODUCTION TO MAP READING

As a terrain analyst, you will read maps to extract information for terrain studies. You will also use a map as a base upon which to add this information to compile your data overlays or special purpose overlays.

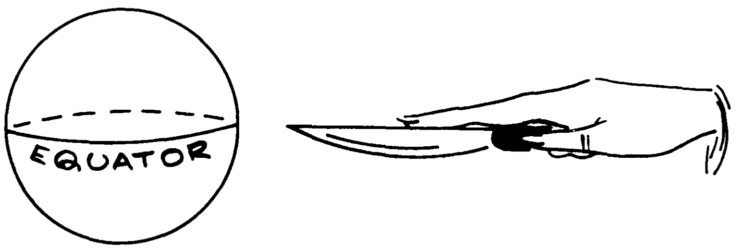
To best understand and use the map information, refer to the legend, which contains symbols of terrain and manmade features shown on the map.

Always look at the legend before using the map. For more details regarding map symbols, refer to FM 21-30, Military Symbols, May 1970, and FM 21-31, Topographic Symbols, June 1971.

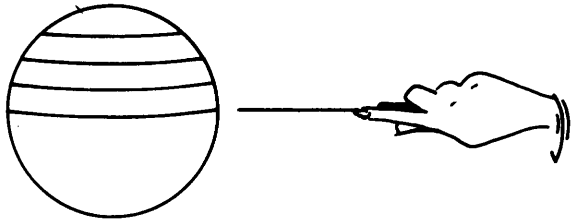
MAP PROJECTIONS

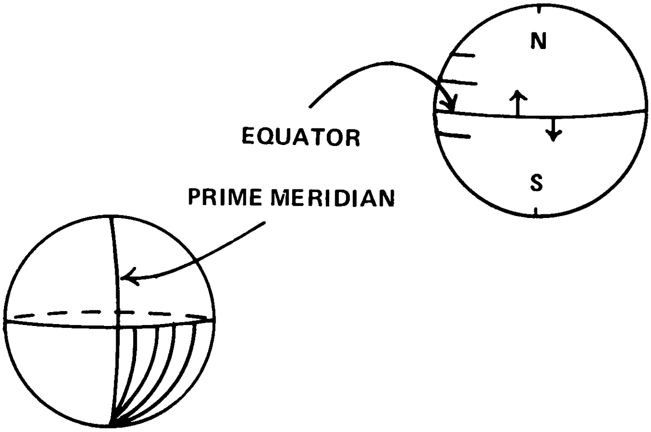
The earth is a globe and a map is flat. There is no way to flatten a globe without stretching or tearing. If you stretch, you distort the areas or shapes of areas to be shown. As long as the area is small, the distortion is not great, as on a city or county map. But when the areas are of continental size, the distortion may be serious. When continents are shown, each with its correct area, the shape is badly distorted.

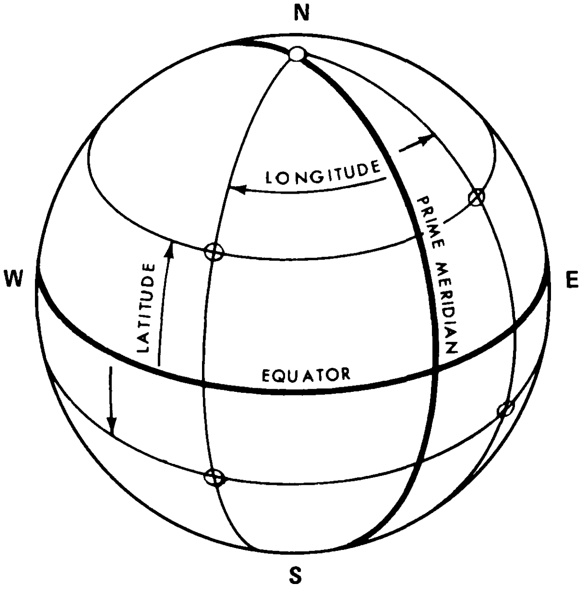
This distortion is a result of "projecting" the shape of the globe, a sphere, onto a flat surface. The first step in making a map projection is to determine geographic coordinates. For a global (worldwide) projection you would mark a sphere where it would slice in two, in the middle, like an orange. This mark is the equator.



Then imagine that you cut the sphere into a number of other horizontal slices of equal distances apart, like slicing an egg. Call these marks "latitude" lines north and south of the equator. Then divide the equator into 360 degrees of "longitude" where each division is sliced through the North and South Poles of the sphere. Let's call the first slice of longitude the prime meridian and number all others east or west of it. The lines of longitude and latitude form the geographic coordinate system described in detail in FM 21-26, chapter 3.





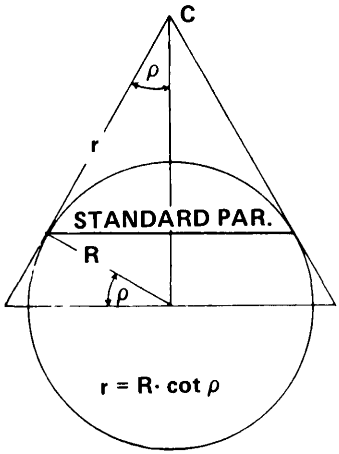


Here is part of the Geographic Coordinate System.

There are many ways to show this coordinate system on a flat paper. One of the most frequently used methods is a conic projection. Imagine that the cartographer (mapmaker) places a cone of paper, like a dunce cap, on a transparent globe. He puts a light bulb in the center of the globe and traces the grid shape and continent outlines on the paper hat. He then unwraps the cone and this is his map of that area. Of course the map is not actually made in this way, but this comparison shows the theory of the conic projection.

More complete details of types of conic projections are presented in TM 5-241-1, Section II and TM 30-245, chapter 5.

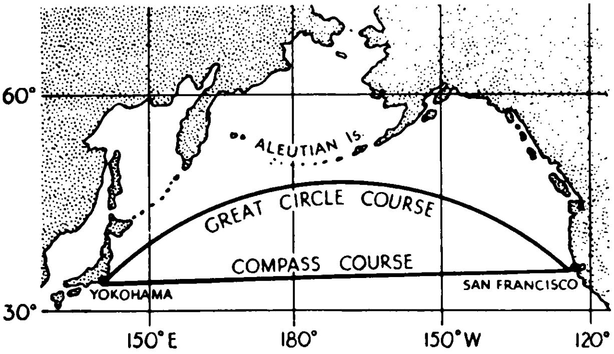
Generally the disadvantage of a conic projection is that the larger the distance between two points on the cone, the larger the distortion and error will be. As a compromise solution to this problem the cartographer uses many differently shaped cones, one for each belt around the earth. This produces a projection called "polyconic", in which the longitude and latitude lines have pronounced bends.



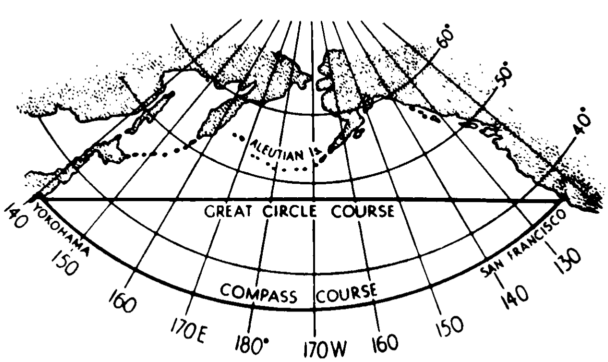
Geometry of
a conic projection.

The projection used for a map depends on (1) the part of the world to be mapped, including both size and location, and (2) the purpose for which the map will be used. Every advantage gained for one purpose (say consistency of scale) must be at the expense of some other factor (such as accuracy of shape).

For navigation, neither shape nor scale is as important as the ability to plot compass courses as straight lines. This is the advantage of the projection known as Mercator, which has been used for centuries in navigational charts. It is easily recognized because the parallels and meridians are all straight lines, and the parallels get progressively farther apart toward the poles. This produces serious distortion of areas in the higher latitudes, but it does not affect the maps usefulness for navigation. For example, if you were to fly from San Francisco to Yokohama and headed due west using a Mercator chart, your compass course would look like this:

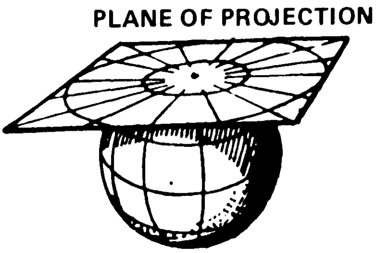


A "great circle", which is the shortest distance between two points on the globe, appears longer on a Mercator projection. So a gnomonic projection was designed in which every great circle appears as a straight line. Gnomonic projections are used to lay out long sailing and flying routes. For descriptions and uses of other map projections, see TM 30-245, chapter 5.



The projection most used by the Army is a modification of the Mercator projection called Transverse Mercator, designed for areas between 84° north and 80° south, where practically all the inhabited land of the earth lies. (See section II, TM 5-241-1 and chapter 3, FM 21-26.)

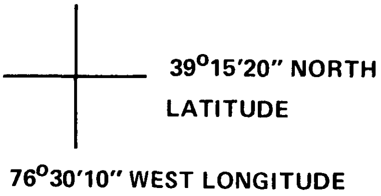
For areas in high latitudes, a Polar Stereographic projection is used. These are the North and South polar regions. In this case a plane is tangent to the sphere at the pole and detail is projected onto it.



POLAR CASE

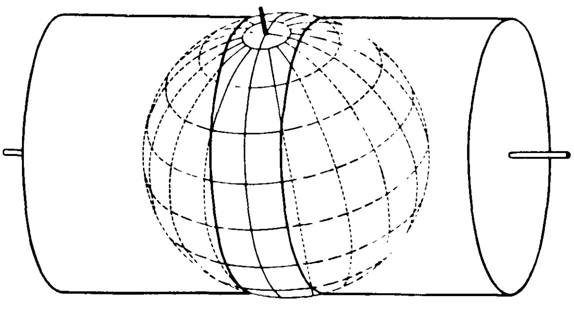
GEOGRAPHIC COORDINATES

Let's go back to page 4-2 where we divide the earth into meridians and parallels. We label the parallels in degrees, minutes and seconds north or south of the Equator and the meridians in degrees, minutes and seconds east or west of the prime meridian. Now we can locate any point on the earth by longitude and latitude. (See TM 5-241-1.)

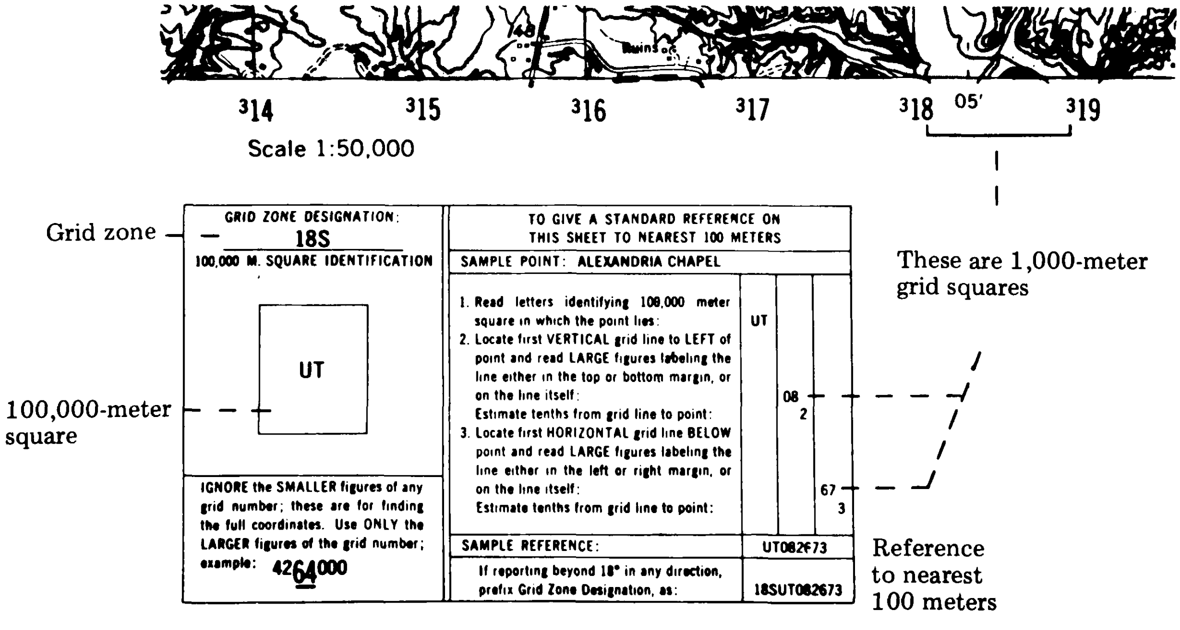


MILITARY GRIDS

Soldiers in the field soon found that giving orders by longitude and latitude to designate exact locations and directions was most cumbersome. To confuse the situation even more, the length of a degree of longitude varies with distance from the Equator. So military grids were designed. Almost every general staff designed its own, however, and soon there were dozens of grids and endless confusion. This all led to adoption by the U.S. Army of the Military Grid Reference System for identifying locations on military maps. This system uses the UTM (Universal Transverse Mercator) grid between 80°S and 84°N latitudes; for the polar regions (north of 84°N and south of 80°S) we use the UPS (Universal Polar Stereographic) grid.



Using the Military Grid Reference System, you will not identify points by latitude and longitude but rather by a series of numbers and letters that designate squares of various sizes on the earth's surface. The largest of these squares are 100,000 meters on each side. They are designated by two letters which place the square within a "grid zone" that is 6 degrees wide (in longitude) and 8 degrees high (in latitude). For example, Fort Belvoir is in 100,000-meter square UT, within grid zone 18S. You can find this information in the lower margin of a map of the Fort Belvoir area (in the Indian Head sheet).



GRID ZONE DESIGNATION:

18S

100,000 M. SQUARE IDENTIFICATION

IGNORE the SMALLER figures of any grid number; these are for finding the full coordinates. Use ONLY the LARGER figures of the grid number; example: 4264000

TO GIVE A STANDARD REFERENCE ON THIS SHEET TO NEAREST 100 METERS

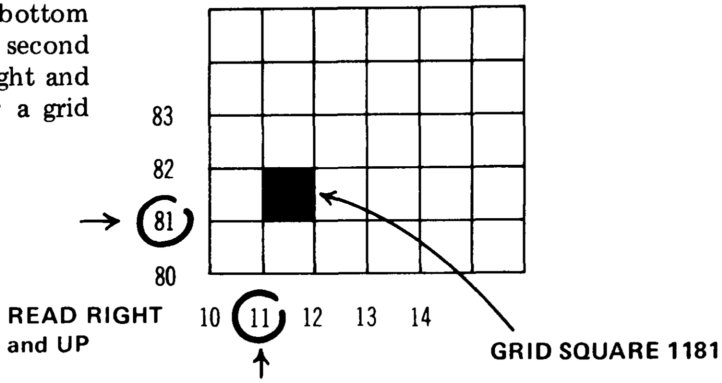
SAMPLE POINT: ALEXANDRIA CHAPEL

1. Read letters identifying 100,000 meter square in which the point lies:	UT		
2. Locate first VERTICAL grid line to LEFT of point and read LARGE figures labeling the line either in the top or bottom margin, or on the line itself:		08	
Estimate tenths from grid line to point:		2	
3. Locate first HORIZONTAL grid line BELOW point and read LARGE figures labeling the line either in the left or right margin, or on the line itself:			67
Estimate tenths from grid line to point:			3
SAMPLE REFERENCE:	UT082673		
If reporting beyond 18° in any direction, prefix Grid Zone Designation, as:	18SUT082673		

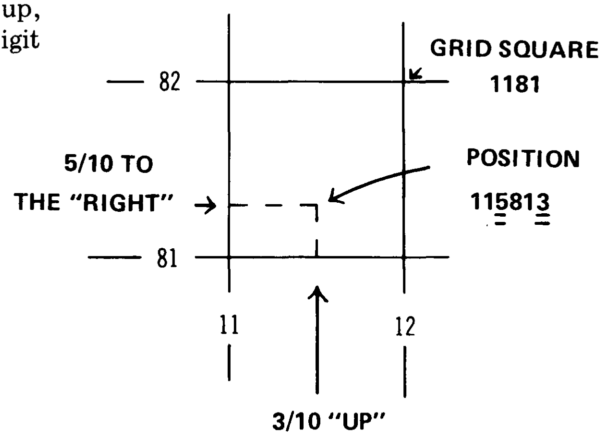
How the Indian Head, MD, VA sheet fits into the

Military Grid Reference System

When you are finding a position on a large-scale topographic map, you are more interested in the 1,000-meter squares, which are called "grid squares." These are identified by a 4-digit number. You get the first two digits by reading the numbers on the bottom of the grid from left to right and the second two by reading up, i.e., you read "right and up." This gives you the number for a grid square.



Now to find your location inside the grid square (to the nearest 100 meters), you need two more digits, one for the horizontal axis and one for the vertical axis. So within the grid square, you estimate how many tenths of the way you are over to the right, and how many tenths of the way up you are. Suppose you are 5/10ths to the right and 3/10ths up, then you insert these to make a six-digit number, such as:

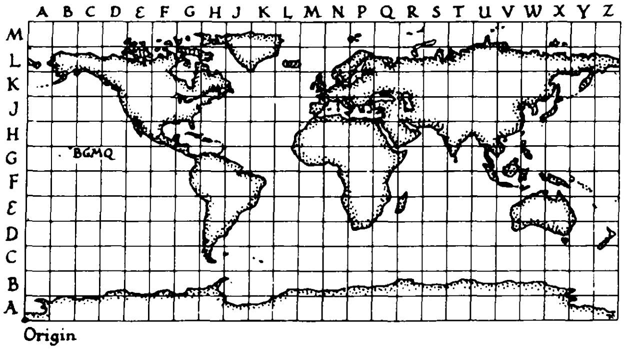


This is just a summary of how we use the Military Grid Reference System. For more information about how it is derived and its worldwide application, see FM 21-26, Map Reading.

WORLD GEOGRAPHIC REFERENCE SYSTEM (GEOREF)

This is a worldwide position reference system used primarily by the U.S. Air Force. It uses geographic longitude-latitude in degrees and minutes with a simplified scheme of reference. The world is divided in 15° bands of longitude, lettered A to Z (with I and 0 omitted). Latitude is also divided into 15° belts lettered A to M beginning at the South Pole. Thus you have 288 quadrangles each identified by two letters. Each quadrangle is subdivided into one-degree squares and marked A to Q. Thus four letters will identify a 1° quadrangle, for example BGMQ. Further details are in FM 21-26.

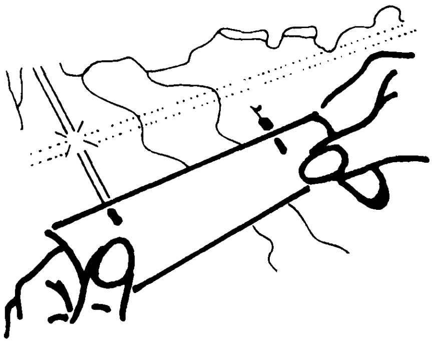
The GEOREF system is used for air navigation and global reference. It uses degrees and minutes but records them by letters and numbers starting from the 180° meridian and the South Pole.



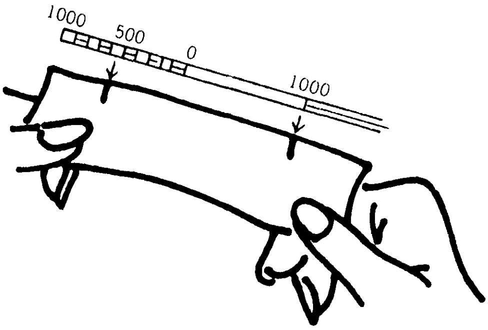
SCALE AND DISTANCE

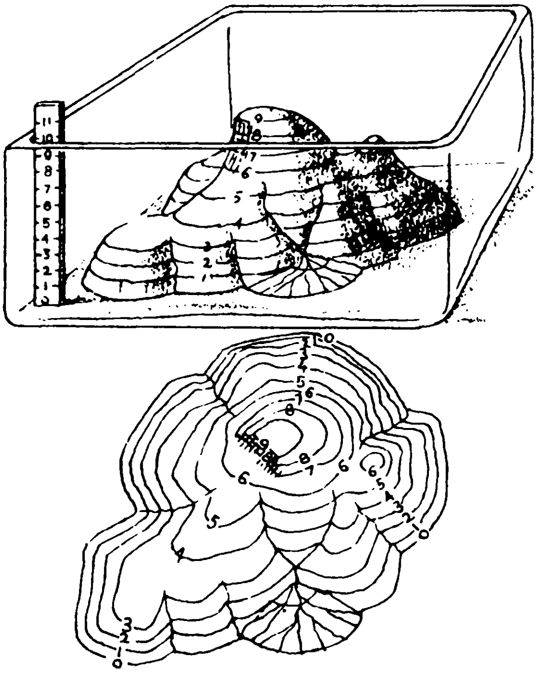
A map is drawn to scale. The scale is printed at the bottom and top of the map like this: 1:50,000. It means that 1 foot on the map equals 50,000 feet on the ground. At the bottom of the map, you'll see also one or more bar scales. Topographic maps used by the Army generally have bar scales in three different units.

Here's how to use the bar scale to measure distance on the ground. Take a piece of paper and mark on it the distance between two points on the map.



Then put this paper, with the two marks on it, next to a bar scale and read on the bar scale what the distance represents. For more details, see FM 21-26, chapter 4.



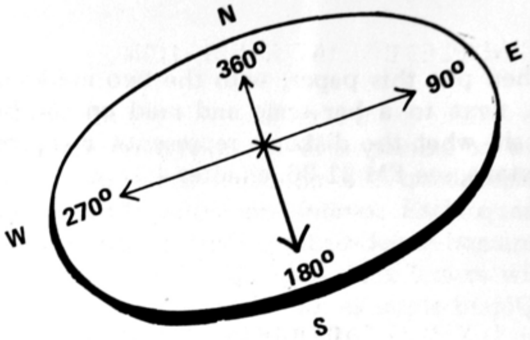


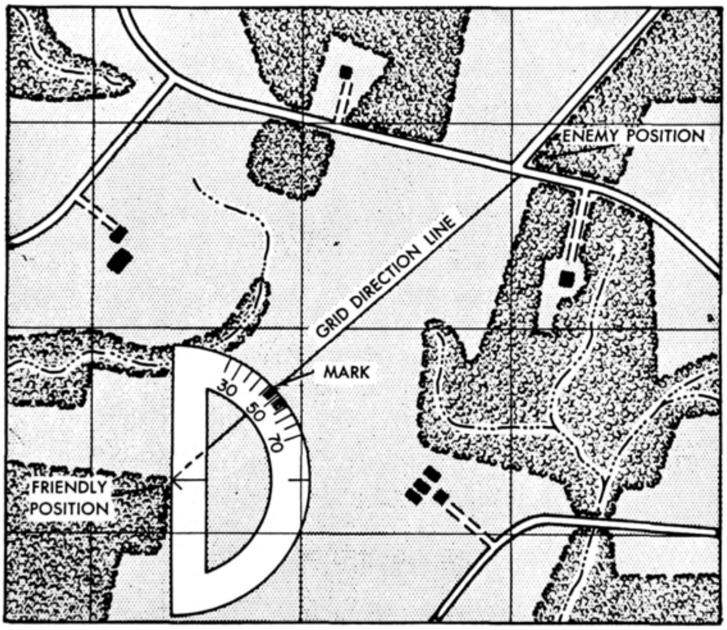
ELEVATION AND RELIEF

How high is the hill and what's its shape? Elevation is the height above a reference plane, usually mean (average) sea level. Relief is the configuration of the terrain. Of the many ways to show relief, the most common way is by contour lines. A contour line is an imaginary line on the ground connecting all points of equal elevation. The spacing and arrangement of contours show the various shapes of the hills and steepness of slopes. Descriptions and illustrations of slopes and shapes such as valley, water basin, ridge, spur, saddle, depression, cut and fills, and cliff, are shown in FM 21-26, chapter 6. Also described and illustrated are other methods of depicting relief such as hachures, shaded relief, and form lines.

DIRECTION AND LOCATION

How to find your location on a map was described on a previous page. Azimuth is read in degrees from north. The compass, like a circle, is divided into 360 degrees. North is 0 or 360°; east is 90°; south is 180°; and west is 270°.





To plot (or measure) the azimuth on a map you will use a protractor. Techniques are covered in great detail in FM 21-26.

PRINCIPLES OF LAND NAVIGATION

Land navigation is the ability of a soldier to find his way cross-country, determining his direction with a compass, the stars, or the sun, and by terrain association, dead reckoning, and map reading. How to do it is described in FM 21-26, chapter 5.

ANALYTICAL PHOTOGRAMMETRIC POSITIONING

This involves the use of geometry and mathematics to determine the position of points on aerial photos involving scale, parallax, and relief displacement. Techniques are described in TM 30-245.

USE OF THE PLANIMETER

A planimeter is an instrument used to measure areas of irregular shapes on maps or photographs. The type that you will use is called a "polar planimeter." This instrument is anchored at one end, and you trace the area's outline with the movable point on the other end. Detailed instructions are furnished with the instrument by the manufacturer.

FOREIGN MAPS

Not all of the maps you will use in terrain analysis will be produced by the U.S. Government. In studying foreign areas, you will often need to use locally produced maps, either because they show details that are not on the maps made in the United States or because they are all that will be available in some situations.

Your biggest problem in using these maps will be one of language. You should have some sort of table of equivalent terms for the language your map is printed in. Sometimes this is given in the margin on an English-language map of a foreign area, or places will be labeled in both the native language and in English. You may have to learn an alphabet that is new or partly new to you, such as Greek or Russian, but you will find that with a little concentration this is not so hard to do.

It pays to learn what common terrain features are called in various languages. For example, in Central Asia a mountain pass might be shan-hou in Chinese, hotol in Mongolian, la in Nepalese and Tibetan, pereval in Russian, or an in Kashmiri. A river would be ho, gol, khola, chhu, darya, and chu in these same languages.

The Army has compiled a summary of the characteristics of the maps of most countries of the world, which you will find useful in any terrain study of a foreign area. This is TM 5-248, Foreign Maps.

SECTION 2. INTERPRET IMAGERY

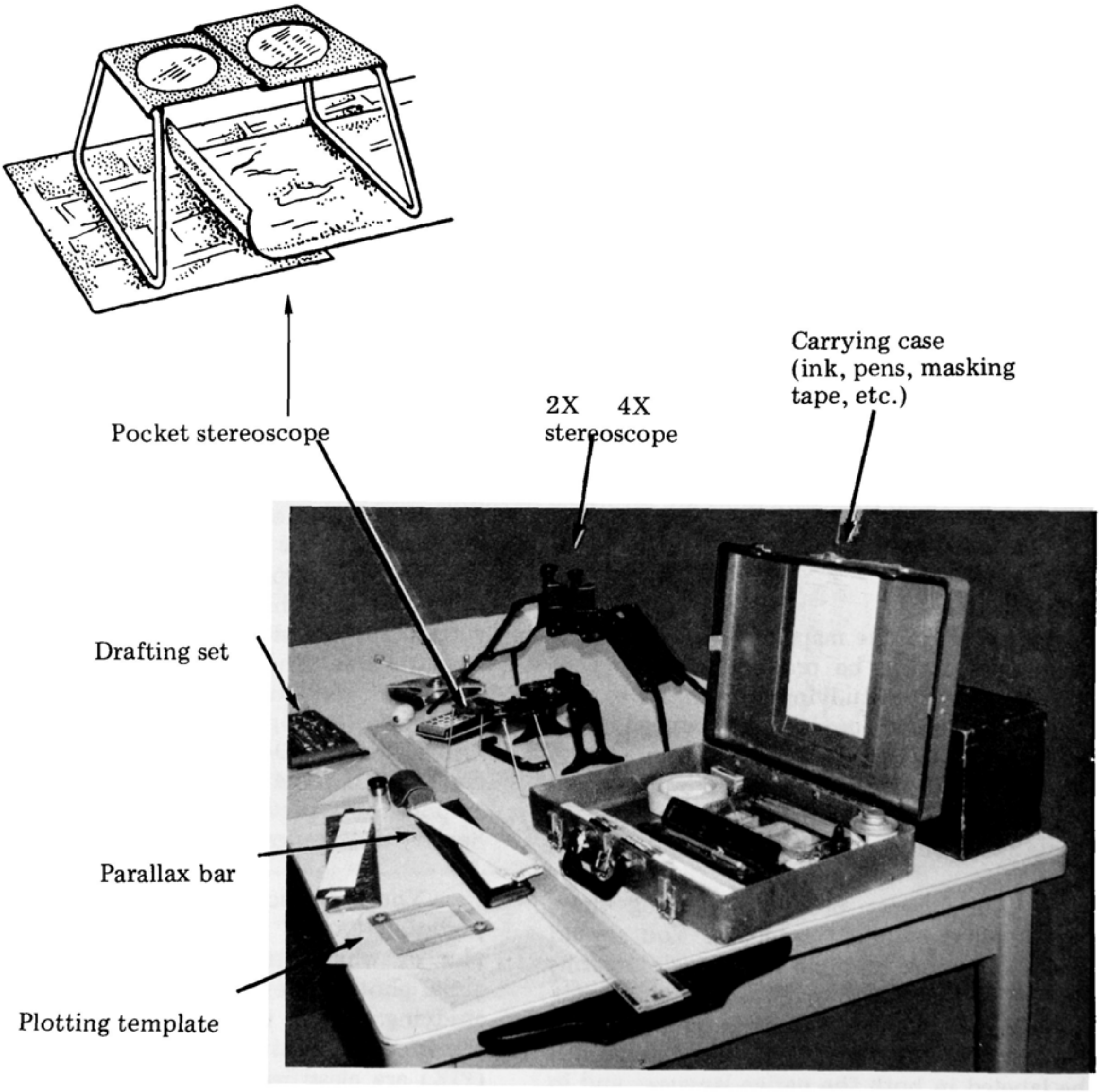
AERIAL PHOTOGRAPHY

Aerial photographs are taken from airplanes with cameras pointed at the ground. The photographs are frequently called air photos. There are many types of cameras and photos, such as high obliques, low obliques, vertical, panoramic, and strip, and many different scales. The interpretation techniques and instruments used range from very simple to extremely sophisticated. These are described in TM 30-246, FM 21-26, chapters 8 and 9 of FM 30-245, and the Manual of Photographic Interpretation by the American Society of Photogrammetry.

You will also make use of photo interpretation "keys." These show typical examples of what terrain features look like on aerial photos. They are essential when you are studying an area that cannot be checked on the ground. Most photo interpretation keys (PIK) are classified, for a listing of them see Appendix A of FM 30-10.

HEIGHT AND DISTANCE DETERMINATION FROM AERIAL PHOTOGRAPHY

Although many extremely sophisticated instruments have been developed to measure distance on aerial photography, some of them operated automatically by computers, the terrain analyst will most frequently use basic and simple techniques. Some of your tools will be the same as those used in photointerpretation and drafting, such as the 2X pocket stereoscope with parallax bar, tube magnifier with a measuring base, drafting tools, plotting template, and photointerpreter's slide rule.



The Terrain Analyst's Office Equipment

PHOTOINTERPRETER'S SLIDE RULE

This slide rule was designed especially to permit rapid calculations of (1) dimensions of objects on photos, (2) scale of photos when altitude and focal length are known, (3) altitude required for a desired scale with a particular focal length, (4) ground covered by any scale of photography, (5) percent of forward overlap, (6) ground distance between adjacent flight lines, (7) exposure interval to meet photo overlap required. You will need to be able to do the first two of these operations on the slide rule; the others are mainly for flight planning. See section 3-10, page 3-63 of FM 30-245 for examples of operation.

PHOTO MOSAICS

You will only need to prepare uncontrolled mosaics, that is, mosaics that are not adjusted to exact measurements. The photos are simply overlapped by matching images and are stapled or glued together. Details are described in TM 5-240, chapter 9.

DRAFTING PRINCIPLES FOR OVERLAY PREPARATION

Overlays are prepared for color separation by pen and ink drafting or scribing techniques described in TM 5-240, chapter 8.

PHOTOGRAPHIC TECHNIQUES IN RECONNAISSANCE

It is often valuable to obtain ground photos using handheld cameras to gather terrain data when on reconnaissance. Their use for this purpose is explained in TM 11-401, TM 11-401-2, FM 5-36, and FM 30-10.

NONPHOTOGRAPHIC IMAGERY

Radar and infrared imagery is mostly supplemental to aerial photointerpretation. For information concerning its use, see TM 30-245, TM (C) 30-245A, Remote Sensing, by the National Academy of Sciences, and Remote Sensing for Environmental Analysis, by J. Estes and L. Senger.

Imagery from satellite transmissions, described on a previous page, is of very small scale (about 1:1,000,000) and still experimental. Its use in terrain analysis is limited to icepack reconnaissance, snow cover, and shoreline measurement. For more information, see the two books on remote sensing listed above.

SECTION 3.

INTERPRET WRITTEN INFORMATION

WHAT TO USE

In chapter 2, we talked about the variety of sources that you can draw on for terrain information. Written sources (in contrast to maps and photographs) are especially diverse since they can be anything from tourist advertising to scientific articles. The important thing to remember is that you should be alert to use any source that can fill in pieces of the "jigsaw puzzle" that we call terrain. You will find travel magazines such as the National Geographic or similar periodicals from other countries especially useful because of the illustrations and maps they contain.

HOW TO EVALUATE IT

Drawing on a variety of sources does not mean you should not be critical of them. On the contrary, you should continually question the accuracy of the written matter that you use, whether it is books, magazine articles, brochures, or whatever. Ask yourself what its purpose was, and whether the author was trying to sell something or had a personal "ax to grind." What do you know about the author? Is he an authority in his field or someone who just visited the area briefly in order to get a quick story? Finally, how recent is the information? If it is 10 or 20 years old, what changes might have occurred in the meantime?

WHAT TO DO WITH IT

There are several ways to handle information from written sources:

1. If you find it to be unreliable and not worth keeping, you should make a note of the source (on a 3x5 card or in a notebook) with your opinion of it so you will not waste time on it again.

2. If you find worthwhile information in it, you should make notes on the card or in your notebook. You can either extract data then and there, or you can write down the kind of data for future reference.

3. Instead of an intermediate file of notes, you can copy the data that you might need directly onto a map overlay or photograph. Remember to show in the margin, or by a symbol of some kind, where the information came from.